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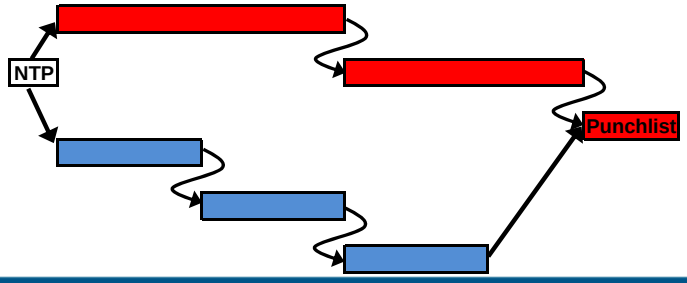
MAKING the DIFFERENCE

Schedules: Back to Basics

I. CPM Scheduling Basics
II. The Baseline Schedule
III. The Schedule Update
IV. Delay Analysis
V. Proving and Tracking Damages

CPM Schedule Basics

- CPM Schedule Logic
- The Critical Path
- Float
- Data Date
- Recommendations



3

"The Basics" - What is a Schedule?

- A schedule is a **TOOL** used primarily to manage time and resources.
- A schedule will force the Party(s) to **PLAN** the construction sequence and timing.
- The schedule provides a means of **TRACKING** progress and forecasting project completion.
- The schedule also provides a method of **MEASURING** the effect of unplanned events and performance.

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"The Basics" - Terms and Components

- **Activity** – A defined piece of work; something required to complete the project
- **Activity Number** – A unique identification for that piece of work
- **Duration** – The number of work days required to accomplish the activity
- **Logic** – The sequential interrelationship of activities
- **Calendars** – Identify what work days and hours activities can be performed

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"The Basics" - Types of Schedules

GANTT or Bar Chart - *a **graphical** representation of what activities will be performed, and when those activities will be performed.*

With a bar chart, the logical relationship between activities and criticality of activities are inferred, but may be unclear. Example:

CPM (Critical Path Method) - *a network of activities with defined durations and logic among activities.*

From a defined start date, CPM schedules can calculate start & finish activity dates and determine the critical path through the logic network.

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CPM Schedule Logic

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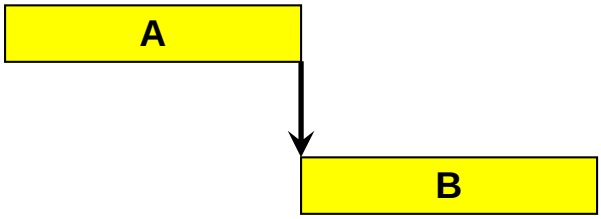
Finish-To-Start (FS) relationship reflects that the activity A must Finish before activity B Starts



Do not confuse FS ties with SF ties, which are rarely used – for good reason.

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CPM Schedule Logic

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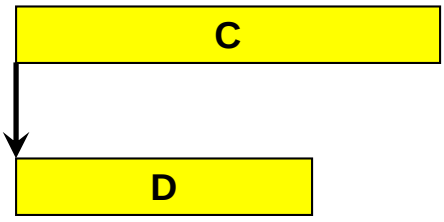
Start-To-Start (SS) relationship reflects that activity D can Start when activity C Starts



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CPM Schedule Logic

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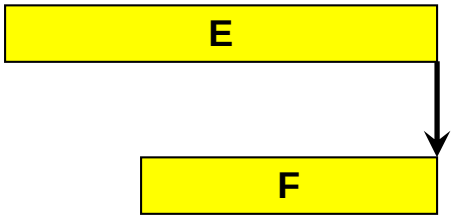
Finish-To-Finish (FF) relationship reflects that activity E must Finish before activity E can Finish



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CPM Schedule Logic

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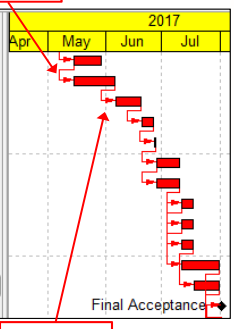
SS tie

Activity ID	Activity Name	Remaining Duration (RD)	Start	Finish
A8060	Sidewalks	10	15-May-17	29-May-17
A8090	Shared Use Path	15	15-May-17	05-Jun-17
A10450	Gaurdrail	10	06-Jun-17	19-Jun-17
A7490	Dress and Seed	5	20-Jun-17	26-Jun-17
A4110	Establish Work Area	1	27-Jun-17	27-Jun-17
A4360	Traffic Signal Mast Arms & Heads	8	28-Jun-17	10-Jul-17
A4380	Traffic Signal Controller Cabinet	8	28-Jun-17	10-Jul-17
A7010	Asphalt Pavement (Surface)	5	11-Jul-17	17-Jul-17
A7160	Permanent Signs	5	11-Jul-17	17-Jul-17
A7165	R/W Monuments	5	11-Jul-17*	17-Jul-17
A4400	Traffic Signal Burn Test	15	11-Jul-17	31-Jul-17
A7180	Clean Site and Punchlist	10	18-Jul-17	31-Jul-17
A1230	Final Acceptance	0		01-Aug-17



FS tie

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CPM Schedule Logic

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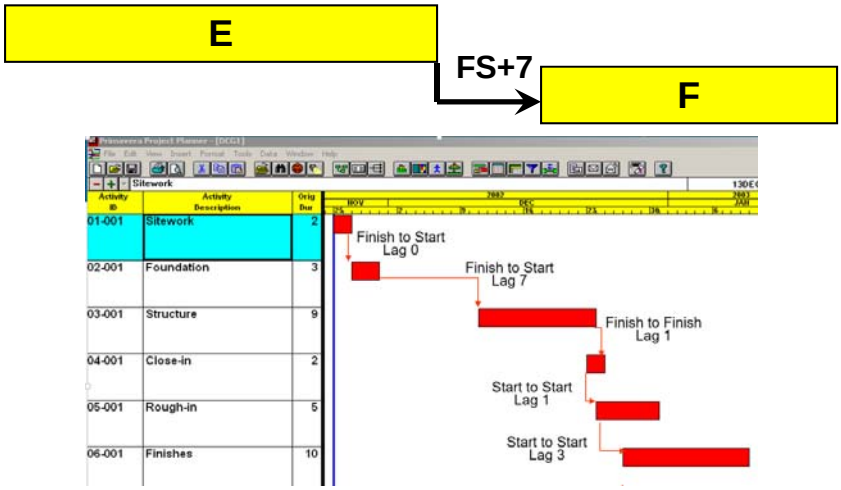
Leads and Lags – offsetting relationships



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CPM Schedule Calendars

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Calendars - show the work days and hours activities can be performed.

Examples:

- Plumbing works M to F, 10 hours/day.
- Electrical works M to Sat., 8 hours/day.
- Civil works M to F, 10 hours/day; Sat., 8 hours/day.
- Curing takes place 24 hours/day, 7 days/week.
- These activities require different calendars to accurately plan the work.

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CPM Schedule Calendars

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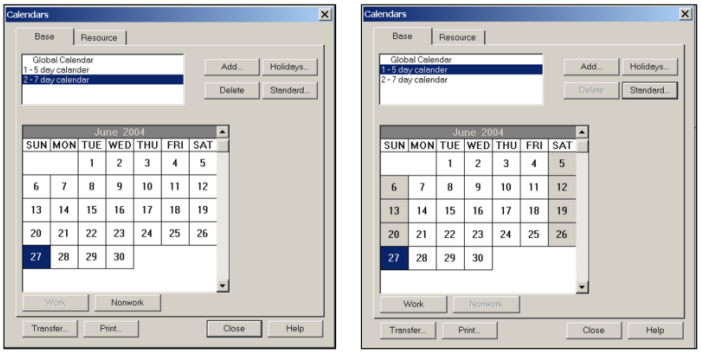
Multiple Calendars



Calendars can be specified for any eventuality making it difficult to follow some of the date calculations in the schedule reviews

CPM Schedule Calendars

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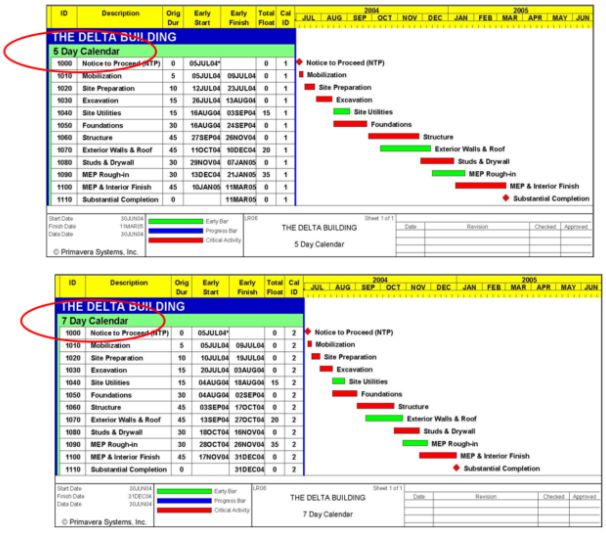

The Critical Path

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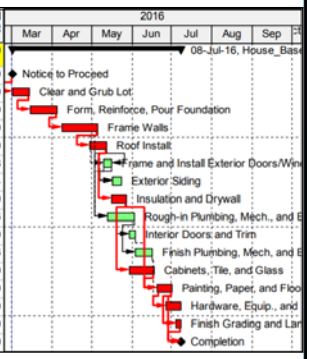
Critical Path - the longest continuous sequence of activities that controls the planned project finish date.

Activity ID	Activity Name	Original Duration	Remaining Duration	Start	Finish	Total Float
House_Baseline Schedule_R0		94	94	01-Mar-16 A	08-Jul-16	0
MS1	Notice to Proceed	0	0	01-Mar-16		0
A1	Clear and Grub Lot	10	10	01-Mar-16	14-Mar-16	0
A2	Form, Reinforce, Pour Foundation	15	15	15-Mar-16	04-Apr-16	0
A3	Frame Walls	20	20	08-Apr-16	05-May-16	0
A6	Roof Install	10	10	29-Apr-16	12-May-16	0
A4	Frame and Install Exterior Doors/Windows	5	5	10-May-16	16-May-16	8
A65	Exterior Siding	5	5	17-May-16 A	23-May-16	34
A7	Insulation and Drywall	10	10	16-May-16	27-May-16	0
A5	Rough-in Plumbing, Mech., and Elec.	15	15	13-May-16	02-Jun-16	6
A8	Interior Doors and Trim	5	5	30-May-16	03-Jun-16	10
A12	Finish Plumbing, Mech, and Elec.	10	10	03-Jun-16	16-Jun-16	6
A9	Cabinets, Tile, and Glass	15	15	30-May-16	17-Jun-16	0
A10	Painting, Paper, and Floors	10	10	20-Jun-16	01-Jul-16	0
A11	Hardware, Equip., and Fixtures	10	10	27-Jun-16	08-Jul-16	0
A13	Finish Grading and Landscaping	5	5	04-Jul-16	08-Jul-16	0
MS2	Completion	0	0		08-Jul-16	0



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The Critical Path

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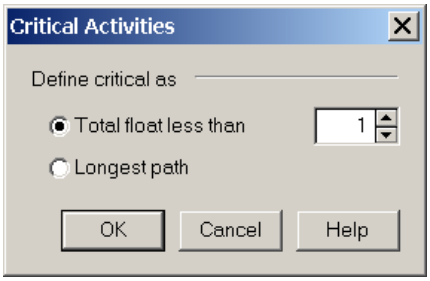
- Software applications determine the critical path differently.
- The most popular software can be set to show activities as critical by Total Float or by Longest Path. (Oh yea…those "red bars" can also be customized.)



- Review how the contract defines the "critical path"; it may vary.

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Total Float

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Total Float – The amount of time an activity can exceed its early finish date without affecting the project end date or other imposed dates. Mathematically, Total Float is the difference between the early finish and late finish dates on an activity.

Caution: Total Float may or may not relate to critical path; its usefulness as a management tool depends on the scheduling techniques used.

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Total Float

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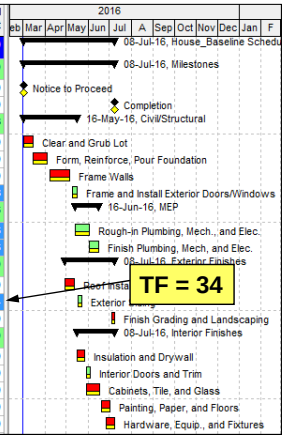
Activity ID	Activity Name	Original Duration	Remaining Duration	Start	Finish	Total Float
House_Baseline Schedule_R0		94	94	01-Mar-16 A	08-Jul-16	0
Milestones		94	94	01-Mar-16	08-Jul-16	0
MS1	Notice to Proceed	0	0	01-Mar-16		0
MS2	Completion	0	0		08-Jul-16	0
Civil/Structural		55	55	01-Mar-16	16-May-16	8
A1	Clear and Grub Lot	10	10	01-Mar-16	14-Mar-16	0
A2	Form, Reinforce, Pour Foundation	15	15	15-Mar-16	04-Apr-16	0
A3	Frame Walls	20	20	08-Apr-16	05-May-16	0
A4	Frame and Install Exterior Doors/Windows	5	5	10-May-16	16-May-16	8
MEP		25	25	13-May-16	16-Jun-16	6
A5	Rough-in Plumbing, Mech., and Elec.	15	15	13-May-16	02-Jun-16	6
A12	Finish Plumbing, Mech, and Elec.	10	10	03-Jun-16	16-Jun-16	6
Exterior Finishes		51	51	29-Apr-16 A	08-Jul-16	0
A6	Roof Install	10	10	29-Apr-16	12-May-16	0
A65	Exterior Siding	5	5	17-May-16 A	23-May-16	34
A13	Finish Grading and Landscaping	5	5	04-Jul-16	08-Jul-16	0
Interior Finishes		40	40	16-May-16	08-Jul-16	0
A7	Insulation and Drywall	10	10	16-May-16	27-May-16	0
A8	Interior Doors and Trim	5	5	30-May-16	03-Jun-16	10
A9	Cabinets, Tile, and Glass	15	15	30-May-16	17-Jun-16	0
A10	Painting, Paper, and Floors	10	10	20-Jun-16	01-Jul-16	0
A11	Hardware, Equip., and Fixtures	10	10	27-Jun-16	08-Jul-16	0



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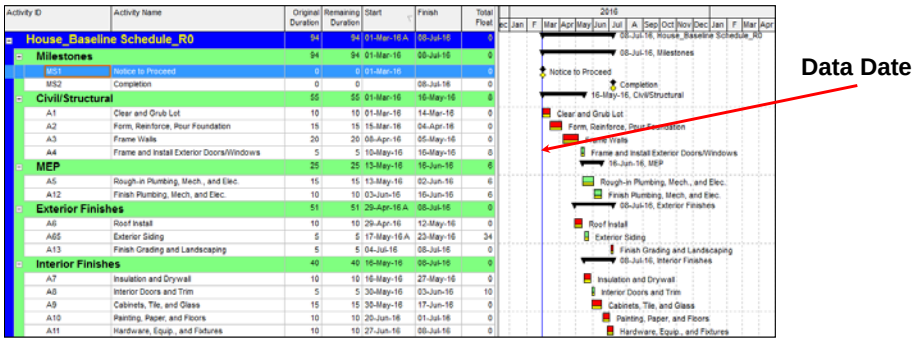
Data Date

The Data Date (DD) is the date through which the project has been updated.

- **As-Built – Left of the Data Date**
- **As-Planned – Right of the Data Date**



Recommendations

- Defined/clear activity descriptions
  - Clarity in understanding activity – better communication
- Keep durations to 20 working days or fewer
  - Keeps progress measurement more objective
- Use FS+0 relationships if possible
  - Easier to understand and forces progress through activity progress, not lead/lags
- Abstain from using constraints
  - Use activities to better communicate/model reason for constraint
- Update once per month or more frequently
  - Schedule is “live”; it changes; keeps team focused on priorities

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The Baseline Schedule

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- Understanding the Contract Requirements
- Creating the Baseline Schedule
  - Internal & External Planning
  - Organizing the Work (WBS)
  - Activities & Durations
  - Schedule Logic
  - Other Items
- Evaluating the Baseline Schedule

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Understanding the Contract Requirements

- The Contract defines the Baseline Schedule Requirements:
  - Contract Milestone Dates or Project Duration
  - Scheduling Specifications
  - Phasing Requirements
  - Timing of Preliminary & Baseline Schedule Submittal
  - Time Extension Requirements
  - Management and Planning for Adverse Weather
  - Schedule Reporting Requirements (narratives & reports)
  - Schedule update frequency and recipients of schedule information
- The Baseline Schedule is the basis from which the contractor's progress will be measured and evaluated

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Creating the Baseline Schedule

Baseline schedule development is an iterative process and generally includes:

- Internal & External Planning
- Organizing the Work (WBS)
- Creating Activities & Defining Durations
- Defining the Activity Network (Schedule Logic)
- Other Items

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Internal & External Planning

- Discuss high-level plans and objectives with project team:
  - What were the bid advantages and strategies for executing the work?
    - Example: Early completion of the work
  - How did the estimating team bid the work?
  - Are there any phasing requirements for the work?
  - Are there special considerations for seasonal activities?
- Develop summary level bar chart and identify timing of key events and phases
- Discuss and develop processes for schedule updating
  - Responsibility for gathering and communicating status information
  - Establish internal schedule update and review cadence

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Internal & External Planning

- Meet with Key Subcontractors and Major Vendors:
  - Communicate summary plan with subcontractors and vendors
  - Understand subcontractor and vendor constraints
  - Request schedule from subcontractors and vendors
  - Identify subcontractor and vendor personnel responsible for providing schedule status information
  - Seek buy-in to the plan from Subcontractors and Vendors
- Review the prime contract and subcontract/vendor scheduling requirements

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Organizing the Work (WBS)

- The WBS allows for the organization of the schedule activities:
  - Organization of activities may be based on:
    - Phasing of the Work (Engineering, Procurement, Construction)
    - Physical Areas of the Work (Plant, Building, Offsite Utilities)
    - Responsibility/Discipline (Civil, Structural, MEP, Finishes)
  - Organization of Activities can also be achieved through activity coding

Best Practice: Use a combination of the WBS and activity codes for quick filtering and organization of tasks based on multiple criteria

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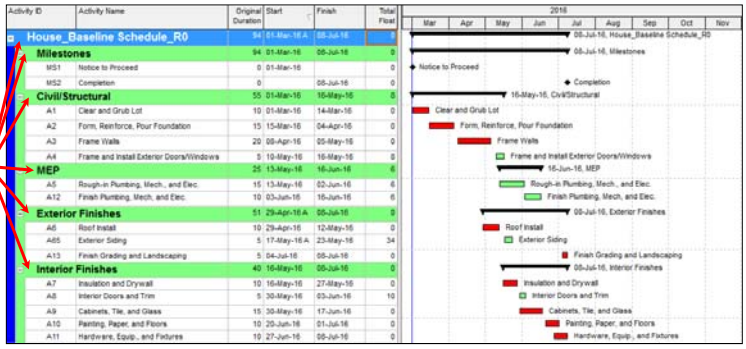
Organizing the Work (WBS)

WBS Headings



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Creating Activities & Defining Durations

- Create activities:
  - Activity names should contain a unique, detailed description of the work that relates to the drawings
  - Activity Types: Task, Resource, Level of Effort, Milestones, WBS
  - Create activities with proper level of detail (too much versus too little)
  - Use Activity IDs to classify and categorize similar types of activities
  - Avoid combining multiple trades/subcontractors into a single activity
    - "MEP" Activities – Mechanical, Electrical & Plumbing Trades
  - Common activities to include in the schedule:

Submittals	Long Lead/Fabrication/ Delivery	Major Inspections	Punchlist
Review Periods	All Field/Construction Activities	Contract Milestones	External Milestones

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Creating Activities & Defining Durations

- Defining Durations:
  - Activity durations should not exceed 20 work days (1 month)
    - Exception for fabrication durations
  - Avoid activities with very short durations (1 to 3 days)
    - Results in excessive activities and difficulty in tracking progress
  - Durations should be reasonable and achievable:
    - May be based on the estimate (labor, equip & mat'ls vs quantities)
    - Use historical or industry production rates
    - Subcontractors and vendors should provide durations for their tasks

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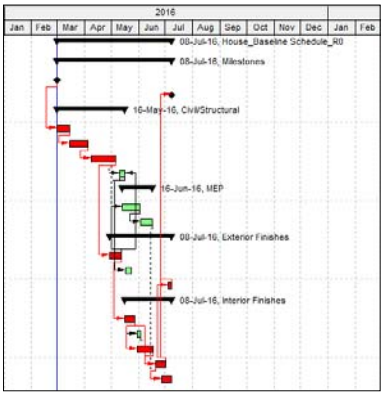
Defining the Network Logic

- Sequencing of the Activities:
  - Use Finish to Start Relationships
  - Minimize the use of Leads & Lags
  - Types of Logic
    - Physical Logic – Foundation complete prior to start of framing
    - Preferential Logic – Crew pours Area A then pours Area B
  - Address open ended activities
    - Missing predecessors
    - Missing successors



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Other Items

- Resources:
  - Resources can be assigned to activities (labor, equipment, material)
  - Allows for the forecasting of resource requirements
- Costs:
  - Costs or Budgets can be assigned to activities
  - Allows for forecasting and calculation of earned value
  - Alignment of schedule activities with the pay application
- Constraints:
  - Avoid the use of constraints as a substitute for logic
- Calendars
  - Multiple calendars can be used to define working periods for different types of activities (7 day week for curing vs. 5 day work week)

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Evaluating the Baseline

Steps for Evaluating the Baseline Schedule:

1. Review the contract & scheduling specifications
   - Does the schedule contain the correct contract milestones?
   - Does the schedule meet the scheduling specifications?
     - Activity durations
     - Submittal review periods
     - No open ends
     - Work period restrictions
2. Schedule versus Scope
   - Does the schedule include activities for the full scope of work?
   - Are activity durations reasonable as compared to quantities/scope?

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Evaluating the Baseline

Steps for Evaluating the Baseline Schedule:

3. Schedule Analytics & Metrics
   - Is the Baseline critical path reasonable?
   - Are there open ended activities (missing logic)?
   - Are the float values reasonable?
     - High float values are an indicator of incomplete logic
     - Low float values for the majority of activities may be an indicator of float sequestration
   - Does the schedule contain activity constraints?
     - Are the constraints necessary?
     - What is the effect of the constraints on the calculation of the critical path?

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Evaluating the Baseline

Steps for Evaluating the Baseline Schedule:

4. Conduct a Formal Baseline Schedule Review
   - Contractor & Subcontractor Review
     - Document assumptions and expectations
     - Ask questions regarding planned labor force and production rates to verify proposed durations
     - Be prepared to revise schedule based on new information
   - Owner & Contractor Review
     - Address non-compliant issues
     - If necessary, request revision and resubmittal.
     - Document the meeting and transmit minutes to the parties
   - Planning and Tracking Inclement Weather Impacts

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The Baseline Schedule - Summary

- The Baseline Schedule is a very important document
- The Contract and Scheduling Specifications define the requirements for the Baseline Schedule
- Baseline Schedule development is an iterative process that requires buy-in from the various project stakeholders:
  - Owner
  - Engineer
  - Contractor
  - Subcontractor & Vendors
- The Baseline Schedule should be manageable, realistic, and representative of the Contractor's execution plan

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Schedules: Back to Basics

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III. The Schedule Update

- Updating the Schedule
- Updating Activities
- Updating Logic
- Other Update Issues

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Updating the Schedule

- Timely
- Actual Performance?
- Proper Input? / Realistic
- Does it reflect the work?
- A schedule becomes out-of-date and useless without updating

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Updating the Schedule

Reasons for Updating

- Contract Requirement – what detail is required?
- Record actual start and finish dates
- Compare actual progress to planned progress
- Forecast dates and resources for remaining work
- Use as basis for accelerating the work schedule
- Use as basis for time extensions

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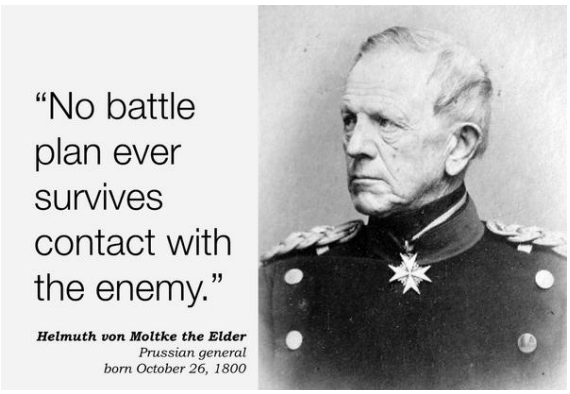
Updating Activities

Typical Issues: Change Orders, Delays, Suspensions and Changed Project Conditions may require modification of activities during updates

- Scope or performance of activities may be affected by change orders, suspensions added or deleted scope, late procurement, permit problems, etc.



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Updating Activities

- Revise activities in updates to reflect changes in planned work scope and execution
- Current and anticipated impacts may require the addition or deletion of activities
- Schedule updates should remain flexible and be adapted to reflect the current plan
- Document revisions: the what and the why

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Updating Logic

- Addressing Out of Sequence Progress
  - Proper use of Retained Logic will address most Out of Sequence Progress situations
  - If the Out of Sequence Progress is actually a change in plan sequence, logic should be revised in the update
- Revised Logic
  - Schedule update logic should be modified to reflect changes in the plan sequence looking forward
  - Document: What changed and Why?

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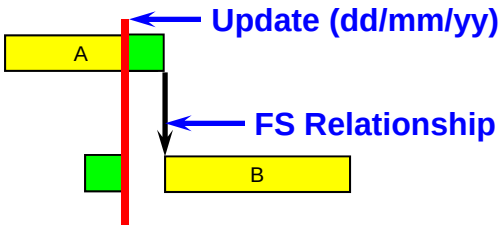
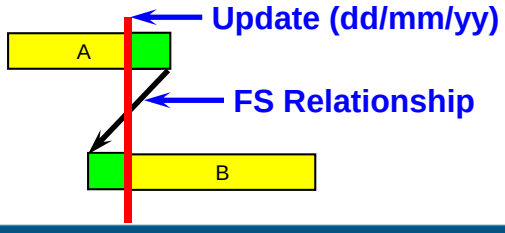
Updating Logic

Out of Sequence Progress

Retained Logic



Progress Override



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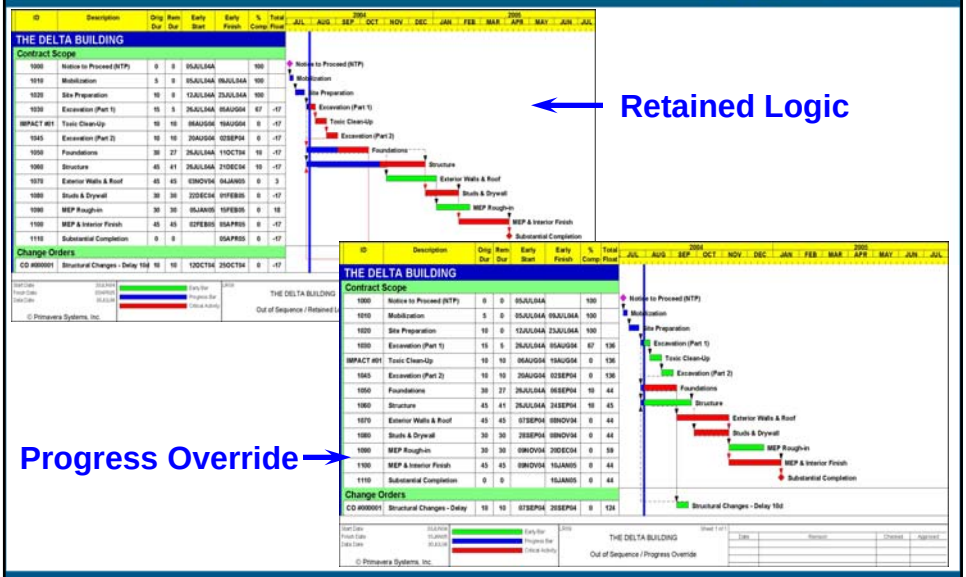
Updating Logic



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Other Update Issues

- As-Built Dates: Real or False
- Project Delays:
  - Retrospective – already reflected by Progress in Update
  - Prospective?
    - ➢ Model with a new Activity / Activities or Discuss in Narrative?
    - ➢ Satisfy Notice Requirements of contract?
- Schedule Comparison Routines: “Claim digger”

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